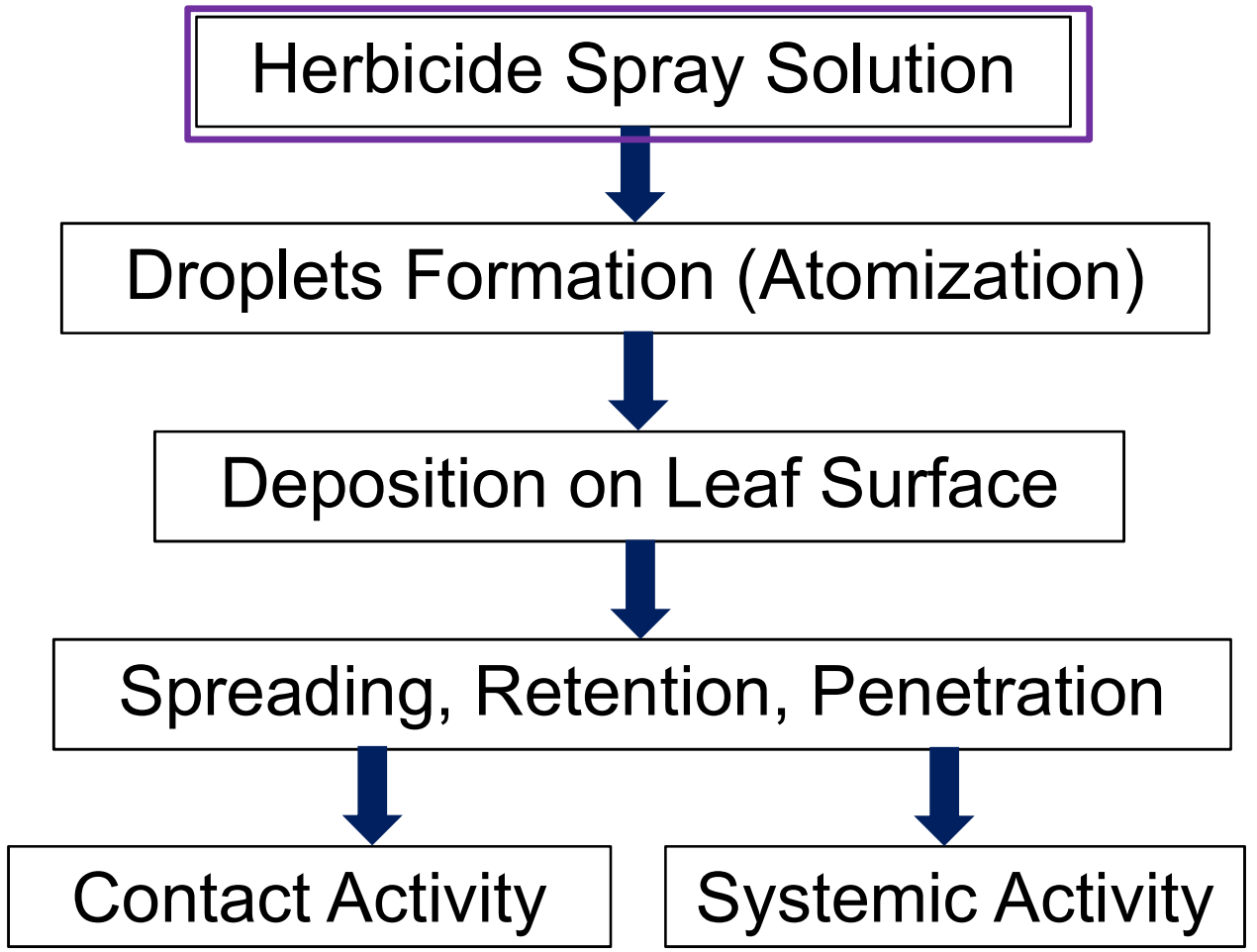
Spray Water Quality:
An Important Consideration for Herbicide Application

Pratap Devkota
UCCE Weed Science Farm Advisor, Imperial County
10/31/2017

Herbicide Application Process



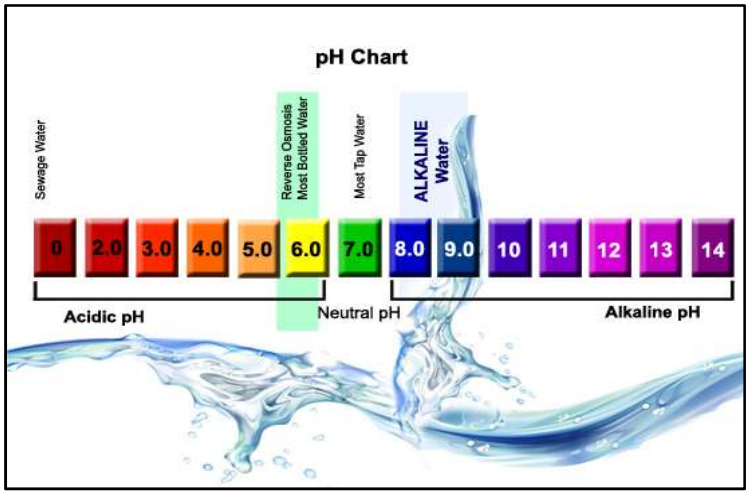
Water: The Major Solvent

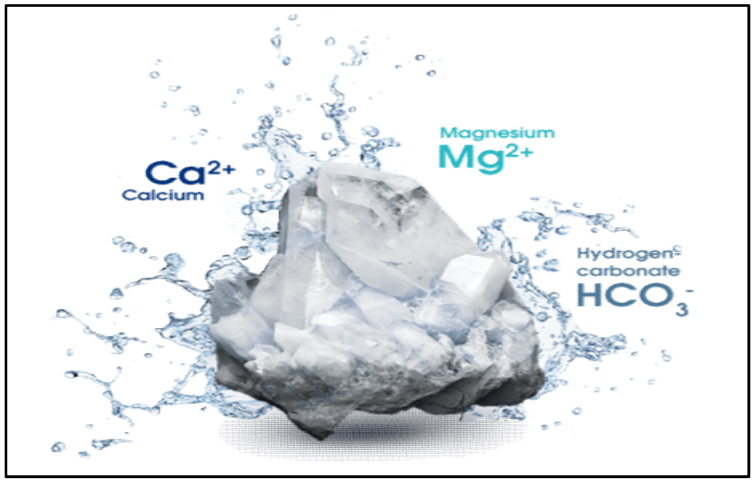
- Water is the primary solvent - comprises >99% of the herbicide spray solution
- Spray water factors:
  - Temperature, turbidity, pH, and hardness
- Inappropriate spray water - negative effect on herbicide

https://ag.purdue.edu

Spray Water Quality

- Turbidity:
  - Amount of suspended particle: inorganic (sand, silt, clay) and organic matter
- pH:
  - Acidity: H^+ ions
  - Alkalinity: OH^- ions
- Hardness: Amount of dissolved minerals.
  - Calcium, magnesium, iron, zinc, aluminum, sodium, potassium

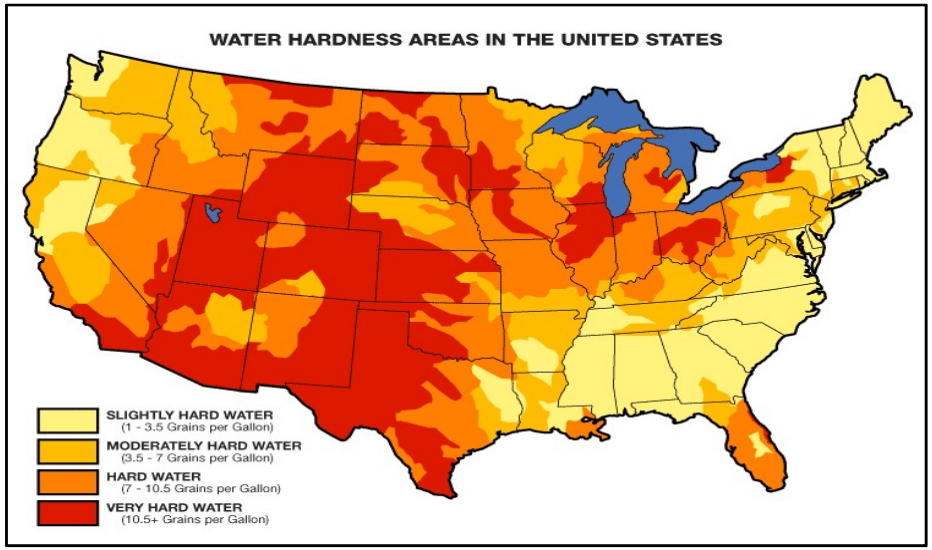




https://www.gerolsteiner.de

Spray Water Quality

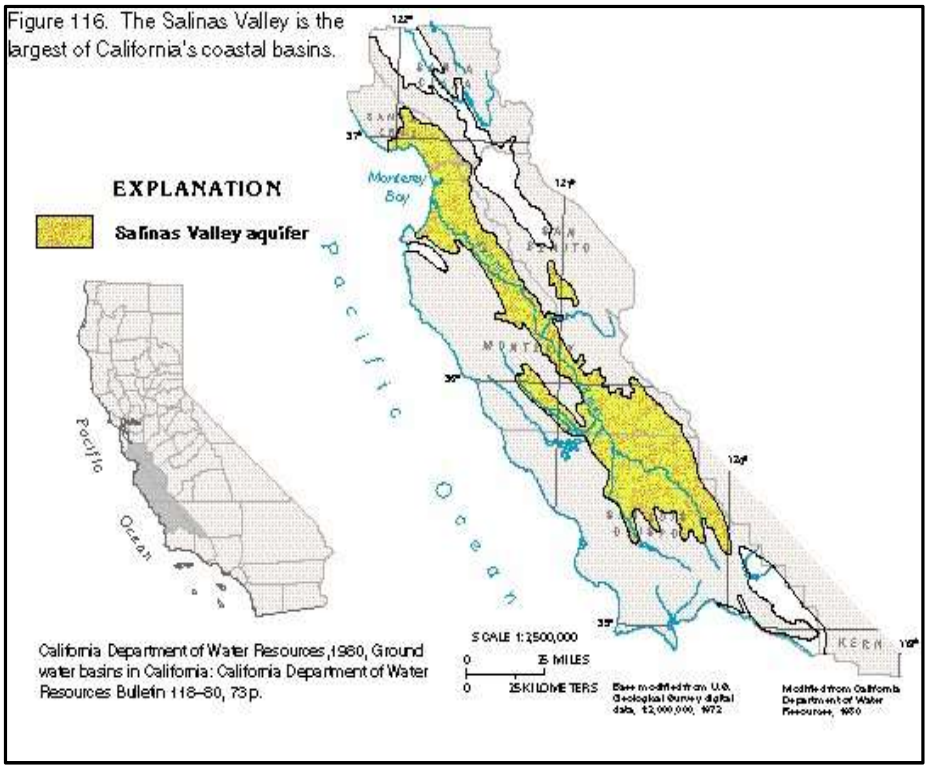
- Spray water quality varies
  - ➢Geographical variation
- Spray water hardness varies in the US
  - ➢Slightly hard to very hard water



Water Hardness Scale/Classification		
Classification	Mg/L (PPM)	Grains/Gal
Soft	<17.1	<1
Slightly Hard	17.1 – 60	1- 3.5
Moderately Hard	60 - 120	3.5 - 7
Hard	120 – 180	7 - 10
Very Hard	>180	>10

http://water.usgs.gov/owq/hardness-alkalinity.html

Spray Water Quality at Salinas Valley



Groundwater in Salinas Valley	
Source	**Value**
Water pH	7.5 - 8
Water hardness (ppm)	50 - 200

Saying It Loud

- Carrier water in this region:
  - ➢Alkaline pH
  - ➢ Moderately hard - hard
- Should we be concerned about compromising herbicide efficacy?

Spray Water Quality

- What does spray water quality research tell us?

- What do we know about effect of spray water temperature, turbidity, pH, and hardness on herbicide efficacy?

Spray Water Temperature & Herbicide efficacy

- Limited research on this topic
- Herbicide performance was reduced at colder (42 F) and warmer (130 F) water temperature
- Optimum temperature was 65 to 100 F
- Response was variable with weed species

Spray Water Temperature & Herbicide efficacy

- Reason not fully understood

- Effect could be:

  - Cold water affecting herbicide droplet size

  - Warm water affecting herbicide molecule breakdown

http://sepn.com.au/embedded-cold-water-networks/

Water Turbidity

- Effect of turbidity depends on K_{oc} value of a herbicide
  - How strongly herbicide adsorb to the soil particle
- Turbidity affects performance of herbicide which has low mobility in the soil
  - Herbicide tie up with the solid particles present in the turbid water

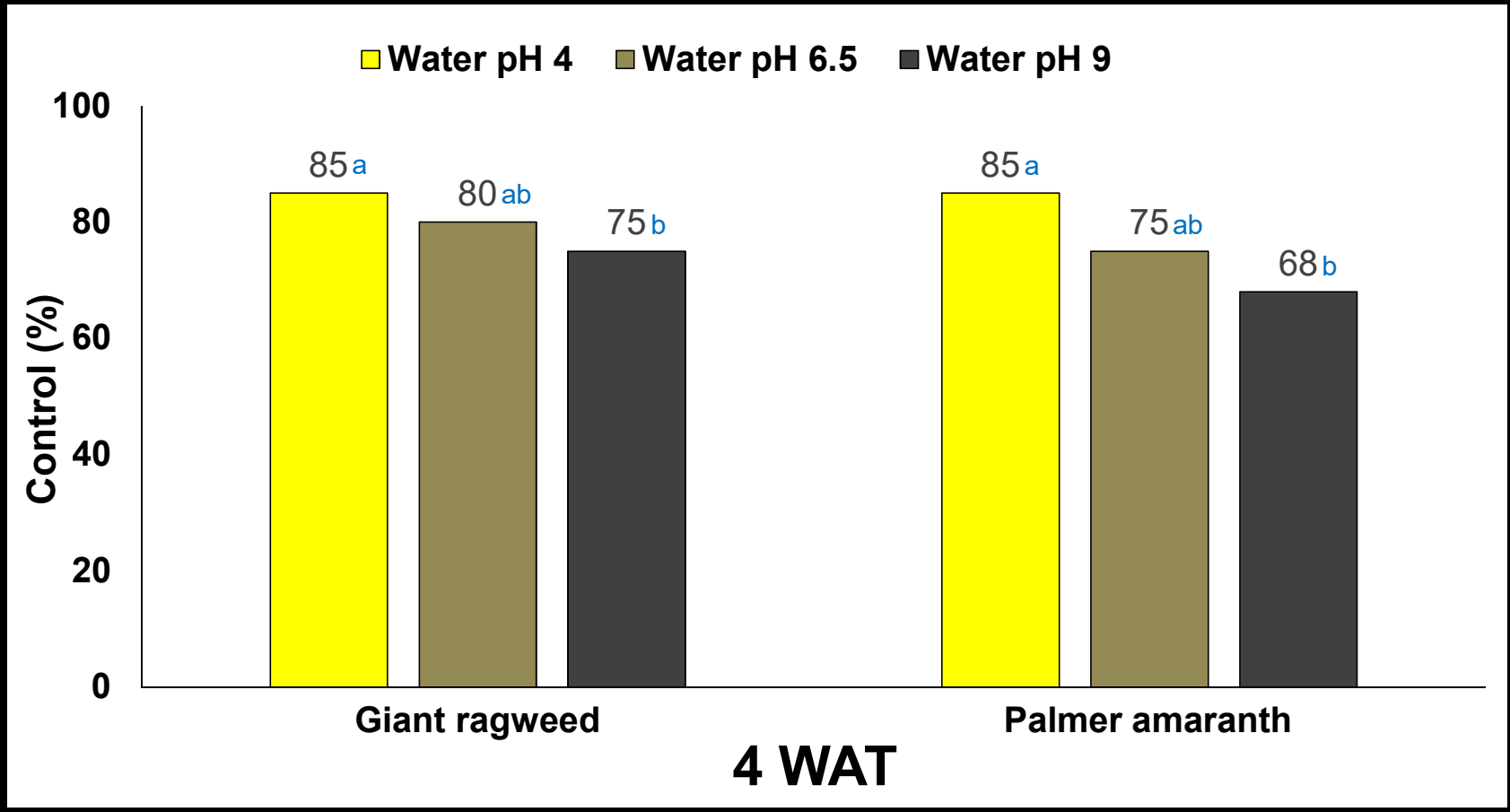
K_{oc} Value and Water Turbidity Effect on Alfalfa Herbicides

Herbicides	K_{oc} value (ml/g)	Effect of water turbidity
Poast (sethoxydim), Sandea (halosulfuron)	< 440	Low
Roundup (glyphosate)	24,000	High
Gramoxone (paraquat)	1,000,000	Very high

http://anrcatalog.ucanr.edu/pdf/8161.pdf

Spray Water pH

- Rely (glufosinate): 29 oz/A



Spray Water pH and Glufosinate Herbicide

Nontreated check

Water pH 4

Water pH 6.5

Water pH 9

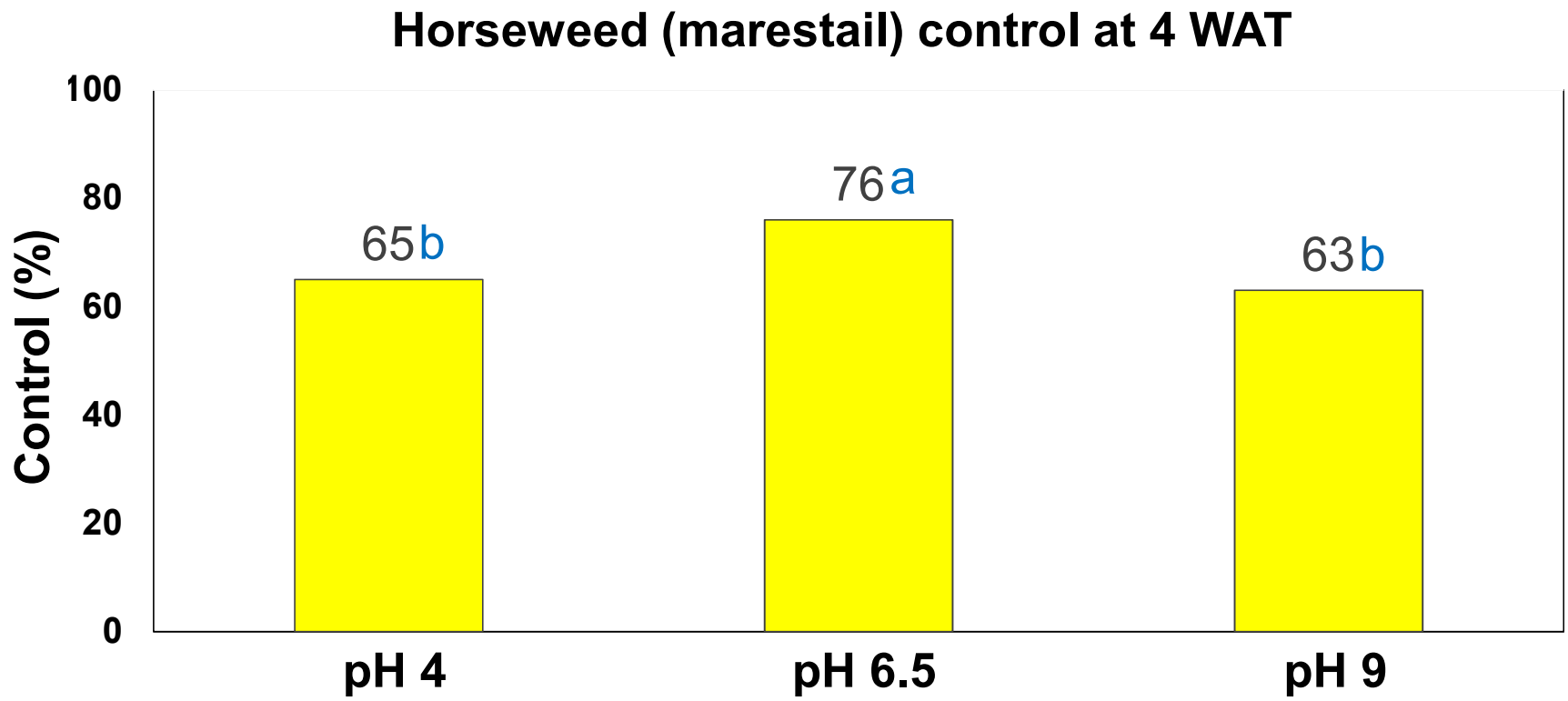
Spray Water pH – Pursuit + Raptor Herbicide

Treatment	Spray water pH	Red rice control with mixture of Pursuit + Raptor herbicide	
		20 DAA	30 DAA
Water source 1	9.4	90 c	89 c
Water source 1	4.5	98 a	99 a
Water source 2	8.7	86 c	88 c
Water source 2	4.5	96 ab	98 a
Water source 3	5.1	88 c	90 c
Water source 3	4.5	95 b	97 ab
Hand weeding	-	98 a	98 a

Sanchotene et al. 2007

Carrier Water pH and Callisto Herbicide Efficacy

- Callisto (mesotrione): 3 oz/A



Carrier Water pH and Callisto (Mesotrione) Herbicide

Nontreated check

Water pH 4

Water pH 6.5

Water pH 9

Spray Water pH and Sharpen Herbicide Efficacy

Table 1. Control of common lambsquarters and giant ragweed at 14 d after application when saflufenacil was applied in water at five different pH levels.[a]

Weed species	pH	Run 1	Run 2
		% control[b,c]	
Common lambsquarters	4.0	15 b	10 c
	5.2	17 b	20 bc
	6.5	55 a	31 ab
	7.7	71 a	45 a
	9.0	58 a	28 ab
Giant ragweed	4.0	44 c	94 a
	5.2	47 bc	97 a
	6.5	69 ab	97 a
	7.7	84 a	98 a
	9.0	80 a	98 a

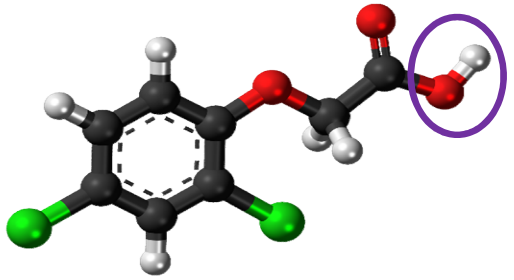
[a] Saflufenacil was applied at 12.5 g ai ha^{-1} with ammonium sulfate at 20.37 g L^{-1} and methylated seed oil at 1% v/v.

Roskamp et al. 2013

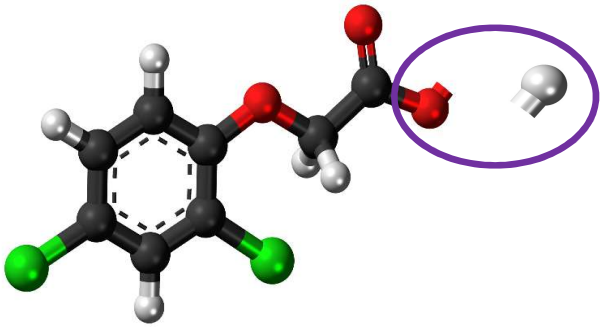
Science Behind the Scene – Spray Water pH

- Duration for an herbicide remaining stable in water (half-life)
  - ➢Alkaline hydrolysis: weak-acid herbicide dissociate (release H^+) and form ionic compound at pH >7
  - ➢Weak-acid herbicides: Gramoxone, Poast, Roundup, Select Max
- Physical stability of adjuvants and surfactants used for herbicide product formulation

2,4 - D



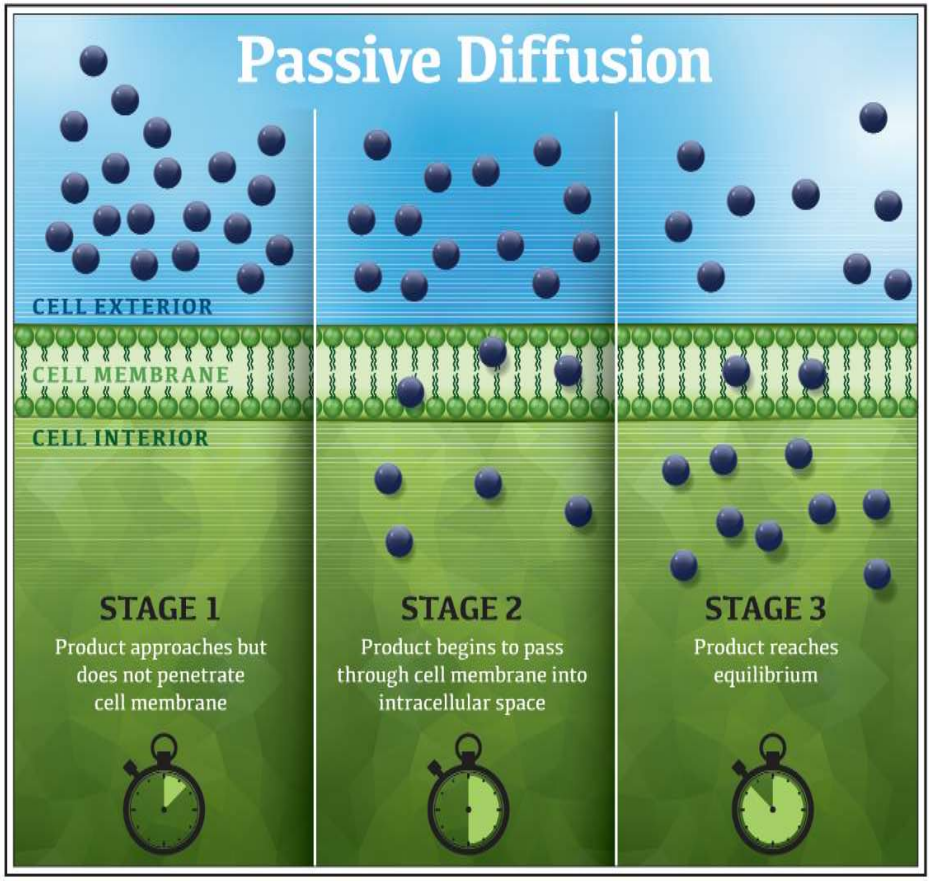
Neutral molecule at low pH



Ionic molecule at high pH

Science Behind the Scene – Spray Water pH

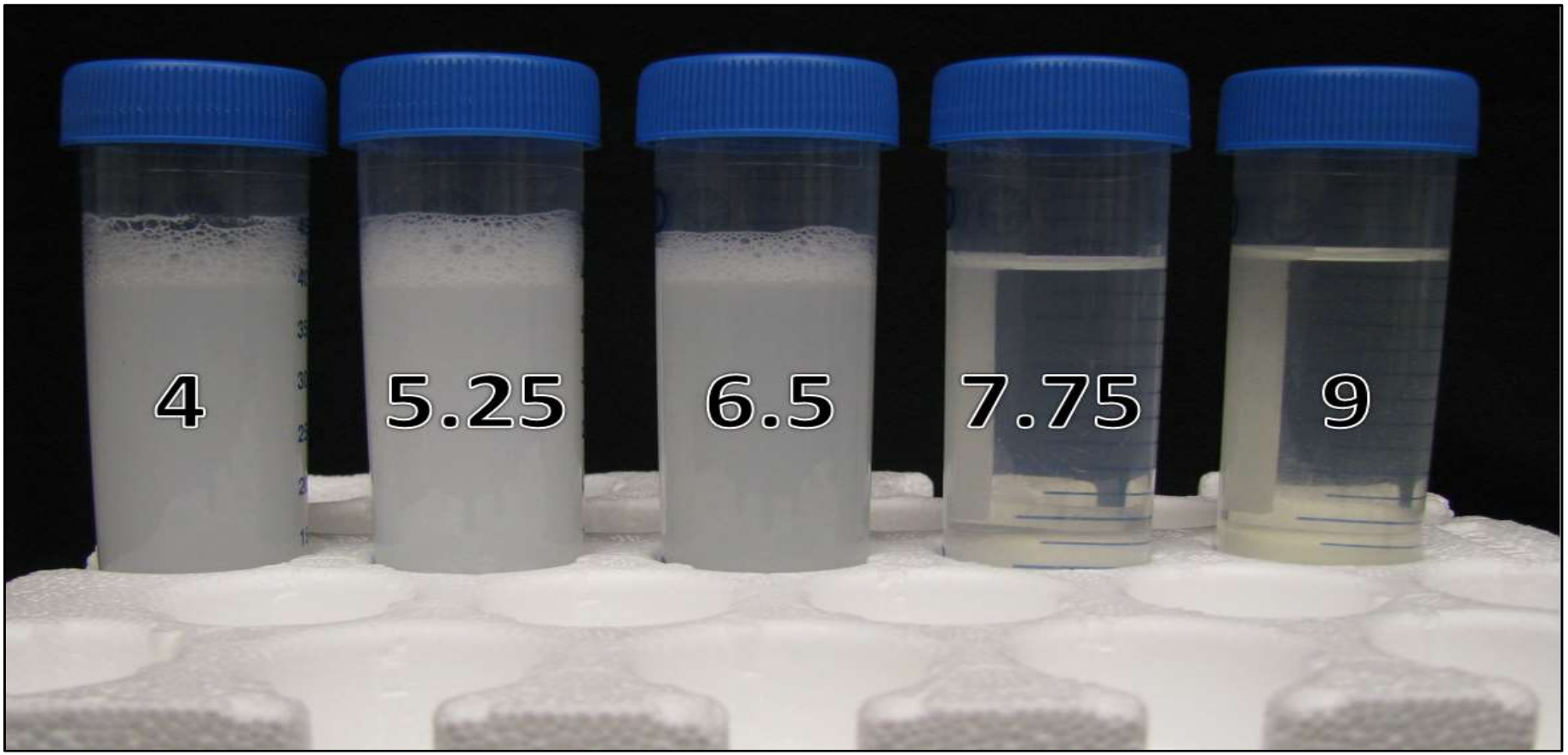
- Herbicide amount getting into the leaf
  - ➢Herbicide uptake
- Herbicide that is not dissociated in the solution gets more into the plant
  - ➢Ionized herbicide have difficulty getting through the leaf barrier and into plant system



https://www. kglandscape.com

Science Behind the Scene – Spray Water pH

- Solubility of herbicide: saflufenacil herbicide



Roskamp et al. (2013), Weed Technol. 27: 527-533

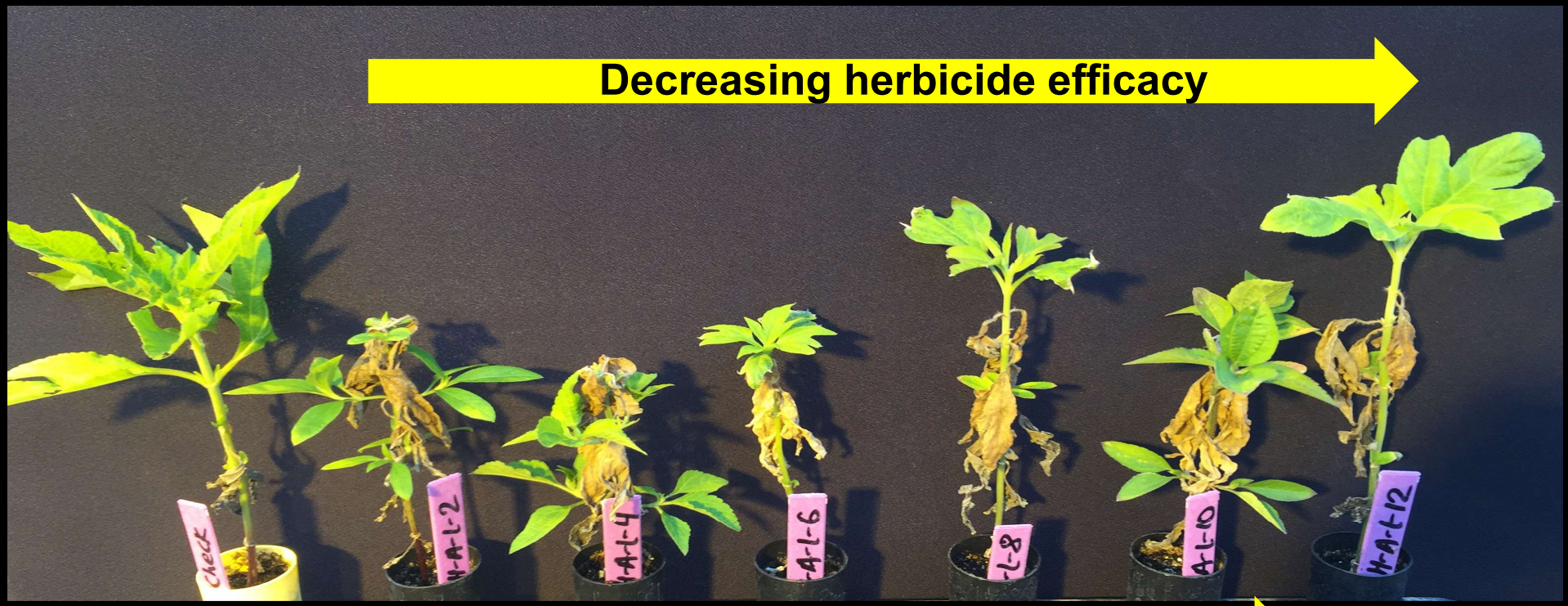
Spray Water Hardness

- What about the effect of hard water on herbicide efficacy?

https://ag.purdue.edu

Spray Water Hardness – Glufosinate Herbicide

- Giant ragweed control with glufosinate herbicide



Hard Water Effect - Varies By Mineral

- Glyphosate efficacy reduction by hardness minerals
  - Iron and Aluminum – Severe
  - Calcium and zinc – moderately severe
  - Magnesium – moderate
  - Potassium and Sodium - none

Spray Water Hardness – Pursuit Herbicide

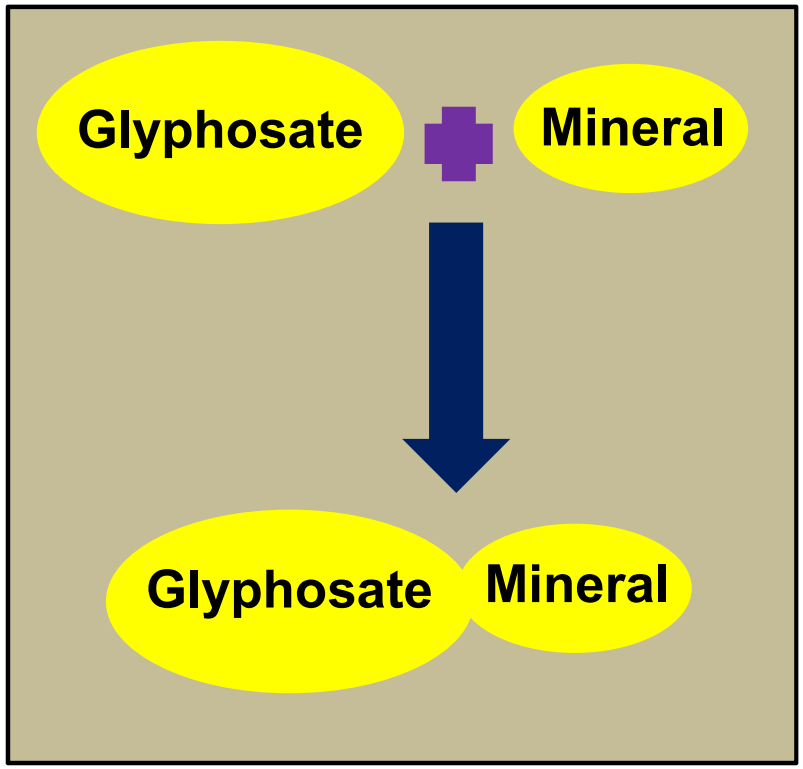
- Pursuit (Imazethapyr) needed to control jimsonweed by 90%

Minerals in spray water	Herbicide needed (g/ha)	
	No AMS	AMS (17 lb/100 gal)
No mineral	32.34 (± 5.90)	12.33 (± 5.90)
Magnesium	52.64 (± 3.36)	14.54 (± 1.89)
Calcium	49.05 (± 8.75)	20.53 (± 2.29)
Sodium	46.2 (± 3.82)	13.65 (± 2.67)

Aliverdi et al. 2014

Science Behind the Scene – Spray Water Hardness

- Mineral bind to herbicide molecule
- Forms stable herbicide-mineral salt complex

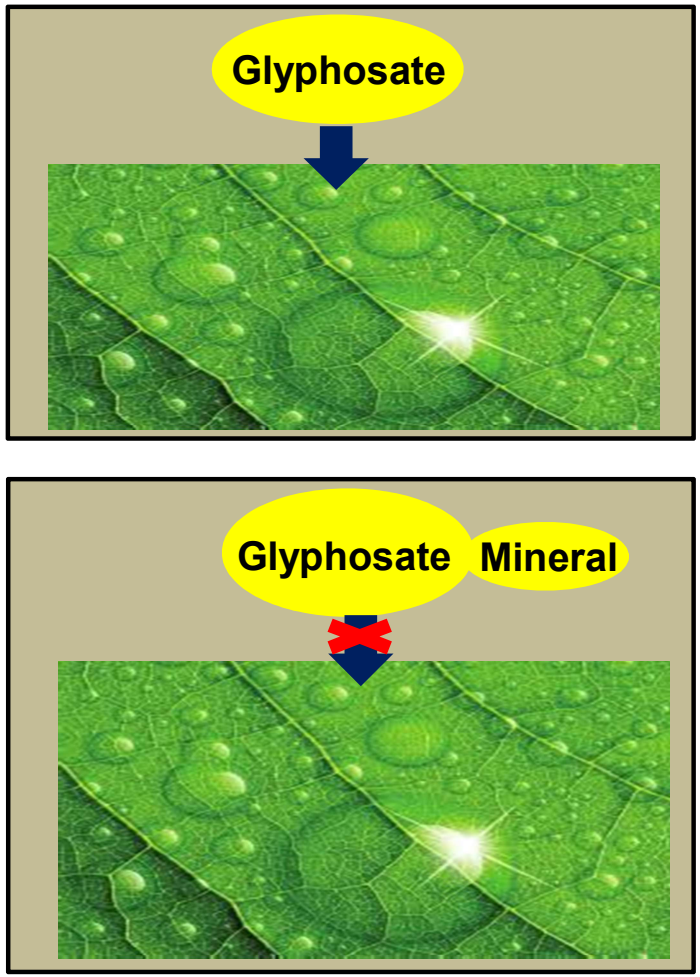


Science Behind the Scene – Spray Water Hardness

- Crystalline deposit of herbicide-mineral complex on the leaf surface

- Reduced herbicide penetration into the leaf

  - Less herbicide amount gets into the plant



https://ag.purdue.edu

Optimizing Herbicide Spray Solution & Application

- Spray water quality - “A piece of the puzzle”

https://www.lerenverbinden.nl

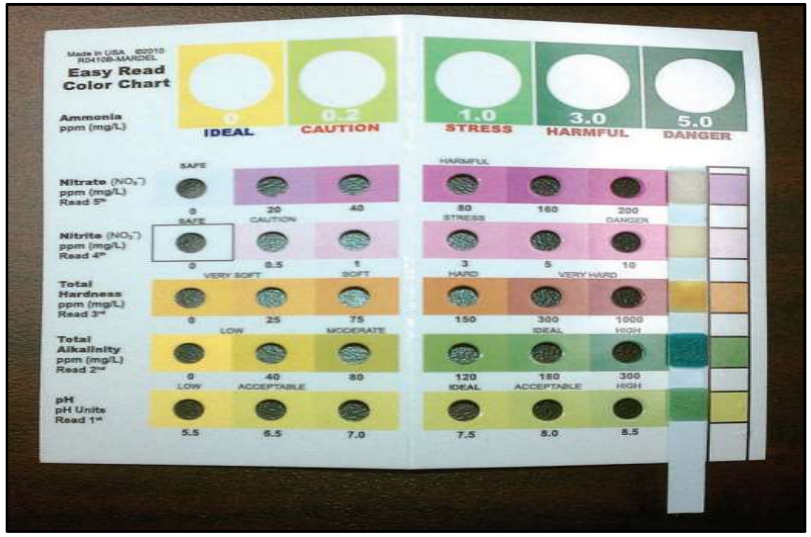
Optimizing Spray Solution – Water Turbidity

- Know the water turbidity:
  - ➢Turbidity could be variable by season
- Know the herbicide Koc
- Use clean water - free of particles
  - ➢Critical for Gramoxone and Roundup application

Optimizing Spray Solution – Water pH

- Know the water:
  - ➢Simple test for acidity/alkalinity
  - ➢Report from water district

- Know the susceptibility of herbicide:
  - ➢Herbicide class and group number?
  - ➢Is it a weak-acid herbicide?



https://ag.purdue.edu

Optimizing Spray Solution – Water pH

- Information on the product label:
  - ➢ Sometime product label includes some comments and information's

Active ingredient	Example of Trade name	Chemical type	Label mixing notes & comments
Bacillus thuringiensis	Dipel	Insecticide	*Use a buffering agent in water with pH greater than 8.5*
Carbaryl	Sevin	Insecticide	*Do NOT mix with Lime Sulphur, Bordeaux mixture or other alkaline materials*
Dimethoate	Dimethoate	Insecticide	Time until half amount of pesticide in water: pH9 = 1 hour; pH6 = 19 hours pH4 = 21 hours*
Diquat and paraquat	Sprayseed	Herbicide	*Water should be clean and free from clay, silt and algae*. [subject to alkaline hydrosis]
Glyphosate	Roundup	Herbicide	*Use only clean water free from soil particles or calcium/magnesium salts (hard water).* *If water is acidic or basic (alkaline) use a recognized buffering agent.*
Iprodione	Rovral	Fungicide	*Unstable in conditions where pH is 7 or higher. Use a suitable buffering agent to bring pH down below 7.*
Maldison	Malthion	Insecticide	Time until half amount of pesticide in water: pH10 = 2 hours; pH8 = 19 hours pH7 = 3 days*
Propargite	Omite	Miticide	Alkaline hydrolysis above pH 7
Trichlorfon	Lepidex	Insecticide	*Alkaline hydrolysis under high pH conditions.* *If using with pH of 8 and above use an acidifying surfactant* (e.g. LI700)

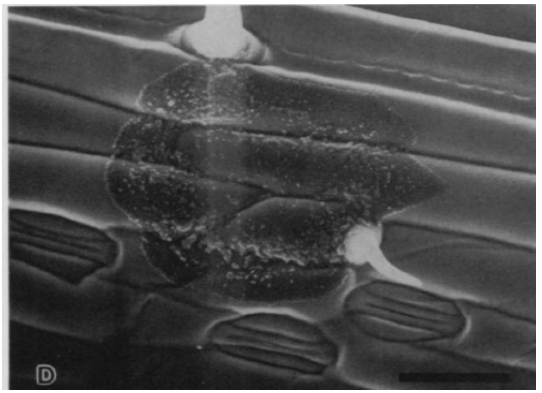
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/433691/Water-quality-for-chemical-spraying.pdf

Optimizing Spray Solution – Water pH

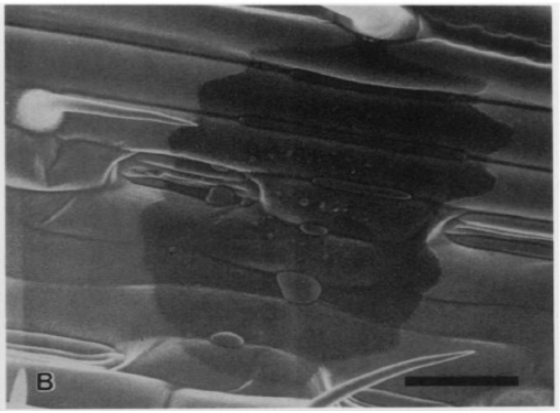
- Adjust the pH:
  - ➢Use of acidifiers or buffering agents
- Do not delay herbicide application after mixing
  - ➢Longer the spray solution stored in the tank greater the chance of herbicide molecule converting to ionic form

Optimizing Spray Solution – Water Hardness

- Use of water conditioning adjuvant
  - ➢Ammonium sulfate as water conditioner
  - ➢Prevents herbicide-mineral crystal deposit on the leaf
- Use herbicide at full labeled rate



Hard water minerals bind to glyphosate forming crystals reducing uptake and efficacy



Ammonium sulfate preventing crystals deposit

https://ag.purdue.edu

Optimizing Spray Solution – Water Hardness

- Following the proper mixing procedure
  - ➢Adding water in tank
  - ➢Adding water conditioning adjuvant
  - ➢Adding herbicide
  - ➢Adding surfactant and crop oil

https://ag.purdue.edu

Moving Forward…

https://ag.purdue.edu

Hard water without conditioner

Optimizing Spray Solution Makes a Difference..!

Hard water with conditioner

Thank You.

Contact:
Pratap Devkota
Phone: 442-265-7708
Email: pdevkota@ucanr.edu